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G131: Supporting the agenda for Safe and Sustainable Cities through Improving Child Safety on the Walk to School

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ABSTRACT

Worldwide, road traffic crashes are the leading cause of death among young people ages 15-29. Road traffic injuries (RTI) prevent approximately one million children annually from obtaining an education. Millions more suffer chronic health problems from air pollution. This results in a lack of education needed to secure future opportunities for employment, contributing to a cycle of poverty.

The majority of children in Sub-Saharan Africa walk to school. For instance, a survey of 2,953 primary school age children in Dar es Salaam, Tanzania found that over 87% walk to school. Walking is a sustainable and healthy mode of transport, but when children's journeys put them in unsafe proximity to traffic, they can be at high risk of road traffic injury and fatality.

An analysis in areas with high rates of RTI, Dar es Salaam, Tanzania, was carried out to identify the effectiveness of speed management around school zones in decreasing RTI.

Light infrastructure traffic calming interventions were implemented at nine public primary school sites in Dar es Salaam, and microwave radar speed guns were used to measure vehicle speeds pre-and post-intervention.

Pre-intervention and post-intervention speed measurements outside of school gates showed a 27% reduction in average speeds and 30% reduction in 85th percentile speeds. Although pre-intervention speeds were lower on unpaved roads compared to paved roads, paved roads saw greater speed reductions post-intervention. Comparing pre-and post-intervention speeds among bicycles, motorcycles, motorized 3-wheelers, cars/taxis, SUVs, mini vans, buses, light trucks, and large trucks, we found that pre-intervention, the speeds of cars and taxis were highest but post-intervention, the speeds of motorcycles were highest.

In conclusion, taken together with studies showing a direct correlation between increased speed and increased risk of injury and fatality, this study shows potential for speed management to protect children commuting to and from school in Sub-Saharan Africa.

KEYWORDS: Speed management, children, school zones, Tanzania, East Africa, road traffic crash, road traffic injury, road traffic fatality

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1.0 INTRODUCTION

Road traffic deaths and injuries are a public health epidemic predicted to increase globally over the next 20 years, if preventative action is not taken (Peden et al., 2004). According to the World Health Organization, road traffic injuries (RTI) will be one of the leading causes of Disability Adjusted Life Years (DALYs) in 2030 (Peden et al., 2004). Low-income countries suffer disproportionately high rates of morbidity and mortality due to road traffic crashes (Peden et al., 2004; Peden et al., 2006).

In response, there is a call to action. The inclusion of road safety in the United Nations Sustainable Development Goals (SDG) heralds a new era for road safety. Whereas road safety was not included in the SDG's predecessor, the Millennium Development Goals, it is now included in this global agenda. SDG 3.6 aims to "by 2020, halve the number of global deaths and injuries from road traffic accidents (Web-1)." SDG 11.2 emphasizes the need to focus on vulnerable populations, stating: "by 2030, provide access to safe, affordable, accessible, and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities, and older persons (Web-1)." Striving to meet such urgent goals necessitates focusing on the most vulnerable populations, in the most vulnerable regions.

While high-income countries have seen a relative decrease or plateau of RTI, low- and middle-income countries have seen the opposite trend (IHME, 2013). The African region has the highest road traffic fatality rate in the world, with 26.6 road traffic fatalities per 100,000 (World Health Organization, 2015). This shows that income is a major factor – it is nearly three times the road traffic fatality rate in the high-income, European region (World Health Organization, 2015). Pedestrians, cyclists, and motorcyclists make up almost half of all road deaths in the world, and consistent with its ranking, the African region also has the highest proportion of pedestrian and cyclist deaths, at 43% of all road traffic deaths (World Health Organization, 2015).

Youth are most at risk of road traffic fatalities. Road traffic crashes are the leading killer of youth ages 15-29 (World Health Organization, 2015), and each day, over 500 children die on the world's roads (Web-2). Many children are killed on their journey to school, walking to class - getting hit while crossing a highway, or falling off a motorcycle (FIA Foundation, 2015). For each child that dies, another four are permanently disabled and ten more are seriously injured (Web-2). Despite the attempt of the UN Convention on the Rights of the Child to try to protect children as a vulnerable population, an estimated 5.5 million children under age 19 have been killed on our roads since the Convention was approved in 1989 (Web-2).

In Sub-Saharan Africa, child pedestrians are among the most vulnerable road users, because they are more likely to walk to school than their peers in wealthy countries, and often do so on dangerous roads with heavy traffic (Guererro, 2011). In Dar es Salaam, we sampled 2,953 children at six broadly representative public primary schools and found that over 87% walk to school (see Table 1).

Table 1: Mode of travel for students in Dar es Salaam, Tanzania

	Walk	Bus	Car	Motor-cycle	3-Wheeler	Train	Bicycle	Ferry	Combined mode	Total surveyed
Total number of students	2587	272	39	26	7	4	3	2	13	2953
Proportion	87.61%	9.21%	1.32%	.88%	.24%	.14%	.10%	.07%	.44%	100%

Using low-cost, strategically placed speed management tools, the non-governmental organization Amend has implemented its School Area Road Safety Assessments and Improvement (SARSAI) programme, which strives to protect children at high risk of RTI in urban areas in two countries with high child RTI rates, Ghana and Tanzania. In Ghana, a door-to-door survey found that 43 of every 1,000 5-14 year-olds were injured in road traffic injuries in 2011 in the Nima and Ashaiman areas of the Greater Accra region (Zimmerman et al, 2011). In Tanzania, 29 out of every 1,000 children were injured in road traffic crashes in the Azimio and Mtoni wards of Dar es Salaam (Guerrero et al, 2011). In response, SARSAI addresses one of the most critical risk factors for road traffic injuries around schools, speed. There is evidence supporting speed management to protect children on their way to school. An evaluation study of 820 locations in New South Wales, Australia where school zone speed

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limits were reduced to 40 km/h showed that casualties among pedestrians ages 5-16 decreased by 46%. The benefits extended to all road users, as the total pedestrian casualty rate decreased by 45% (Graham and Sparkes, 2010). Reducing speed is key to reducing RTI (Figure 1) (Tingvall and Haworth, 1999).

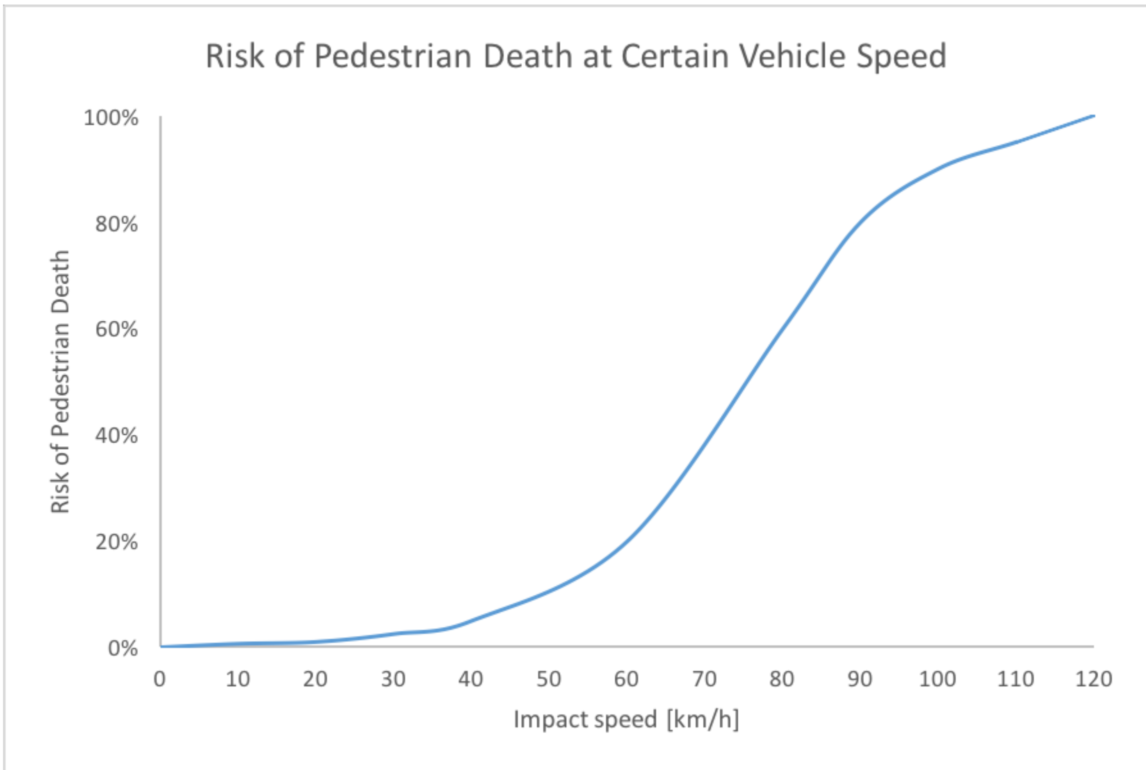

Figure 1: Relationship between speed and risk of pedestrian death

The likelihood of a crash, and resulting injuries, decreases as speed is reduced (Web-3 and Elvik, 2009). This correlation is particularly strong among pedestrians, cyclists, and motorcyclists (Rosen, 2011). A 5% cut in average speed can result in a 30% reduction in the number of fatal crashes (World Health Organization, 2015). Moreover, managing speed, which contributes to both crash occurrence and crash severity, represents a realistic approach to the road safety Sustainable Development Goal in the existing timeframe (Job and Sakashita, 2016, in press).

The goals of this study were to evaluate the effectiveness of SARSAI in: decreasing vehicle speed and RTI in nine intervention schools; demonstrating the scalability of SARSAI; refining materials and methods of implementation; and measuring the change in interim indicators for road traffic injury (such as vehicle speed and road use) resulting from the programme.

This study is part of a larger study by Amend in Dar es Salaam, Tanzania. Amend carried out a population-based study to measure RTI rates and characteristics before implementing road safety interventions, and is in the process of collecting data post-intervention at the nine 'intervention' schools and at nine 'control' schools. Findings from the population-based study will be published separately. However, an important initial finding shows that prior to any interventions, approximately 92% of all injured pupils at selected schools were pedestrians, an estimated 63% of RTI occurred on a journey to or from school, and approximately 48% of all injury cases involved a child being hit by a motorcycle.

The eventual findings from the population-based study as well as this speed data study can help policy makers, the media, and other stakeholders in both the programme countries, and globally, understand the potential for such a low-cost, life-saving intervention. This baseline data will also help gauge the effectiveness of interventions over time, to compare this setting with others.

2.0 METHODS

SARSAI interventions were conducted at nine school sites in Dar es Salaam, Tanzania. Some school sites contained more than one school. Data was gathered at each school site to estimate the

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change in vehicle speed in the selected school districts pre- and post-SARSAI interventions. SARSAI interventions included speed humps made from asphalt for paved roads, speed humps made from cement stabilised natural gravel for unpaved roads, rumble strips, signage to designate reduced speed limits and pedestrian crossings, zebra crossings with cross-over slabs over open drains, and bollards to mark off areas for pedestrians.

2.1 Study setting

The study took place in Dar es Salaam, Tanzania. Data was collected directly outside the school gates at nine of our SARSAI schools sites. Five sites had paved roads outside the school gate and four sites had unpaved roads outside the school gate.

2.2 Sampling strategy

Pre-intervention data was first collected at each location prior to infrastructure improvements. Thereafter, within a month of the completion of infrastructure improvements, post-intervention data was collected.

At each location, data was collected during two time periods on Tuesday, Wednesday or Thursday, over a one hour period. The one hour periods corresponded with school opening and closing times: 6:30am to 7:30am, 11:00am to 12noon and 2:00pm to 3:00pm. The two time periods for each site were randomly selected for all pre-intervention data. Post-intervention data was collected at the same locations, during the same time periods as the pre-intervention data to control for confounders.

Using microwave-radar speed guns, data was collected from all vehicles passing the point of data collection. Observations were conducted for 60-minute sessions without break, and were made on vehicles traveling in one direction at the observation location. Due to high traffic volume, it was not always possible to collect data from each passing vehicle. In these circumstances, the speed of the vehicle closest to the observer was recorded.

2.3 Data management

A conservative estimate was used on expected impact of the interventions. A study in Italy showed a 1-18% reduction for the 85th percentile of vehicle speed after the installation of speed bumps (Pau, 2001). As there was a lack of baseline information on current average traffic speed at the sites prior to the study, the study used 10% as the effect size in reducing traffic speed. Cohen's d effect size for a t-test can be seen in Eq (1).

(1)

$$d = \frac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{(\sigma_1^2 + \sigma_2^2)/2}} \quad (1)$$

Table 2 shows the projected sample size required, Table 3 shows the sample size achieved.

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Table 2: Projected Sample Sizes

Sample size per group		Power		
		0.8	0.85	0.9
Effect size	0.05	6281	7184	8408
	0.10	**1571**	1797	2103
	0.15	699	800	936

Table 3: Achieved Sample Sizes

Sample	**Sample Size (Vehicles Surveyed)**	
	Pre-intervention	**Post-intervention**
All Sites (9 sites)	1,873	1,921
Paved Sites (5 sites)	1,535	1,468
Unpaved Sites (4 sites)	338	453

3.0 DISCUSSION

At nine school sites where SARSAI was implemented in Dar es Salaam, Tanzania, pre-intervention and post-intervention speed measurements outside of the schools' gates showed a 30% reduction in 85th percentile speeds. The 85th percentile speed is the speed at or below which 85% of all the vehicles travel past a particular point in free flowing conditions, and is commonly referred to as the 'operating speed'. Table 4 shows a summary of both the 85th percentile speeds and average speeds pre- and post-intervention.

Table 4: Speed Data Analysis Summary

Location	**Speed (km/h)**			**% Difference**
	Pre-intervention	**Post-intervention**	**Difference**	
All Sites				
- Average	27.1	19.7	-7.4	-27%
- 85th Percentile	37.0	26.0	-11.0	-30%
Paved Sites				
- Average	28.6	20.3	-8.2	-29%
- 85th Percentile	39.0	26.0	-13.0	-33%
Unpaved Sites				
- Average	20.5	17.6	-2.9	-14%
- 85th Percentile	26.0	21.0	-5.0	-19%

Although pre-intervention speeds were generally lower on unpaved roads compared to paved roads, there were greater speed reductions on the paved roads.

All types of vehicles did not see the same reduction in speed. For paved roads, even though motorcycle speeds were not the highest pre-intervention, their speeds did not drop as much as the other vehicle categories post-intervention. Motorcycles also seem to pose a particular danger on unpaved roads, as they had the highest speed. 85th percentile speed graphs are shown below by vehicle category.

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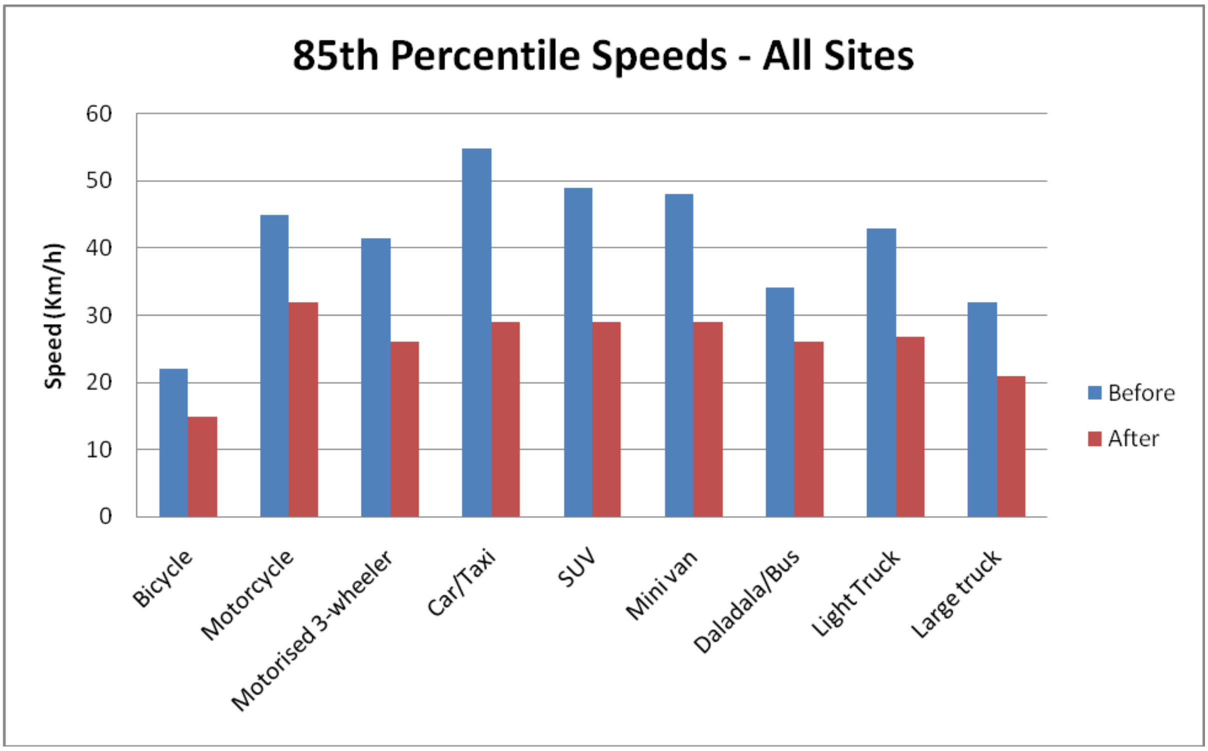

Figure 2: Pre- and post-intervention speed by vehicle type, all sites

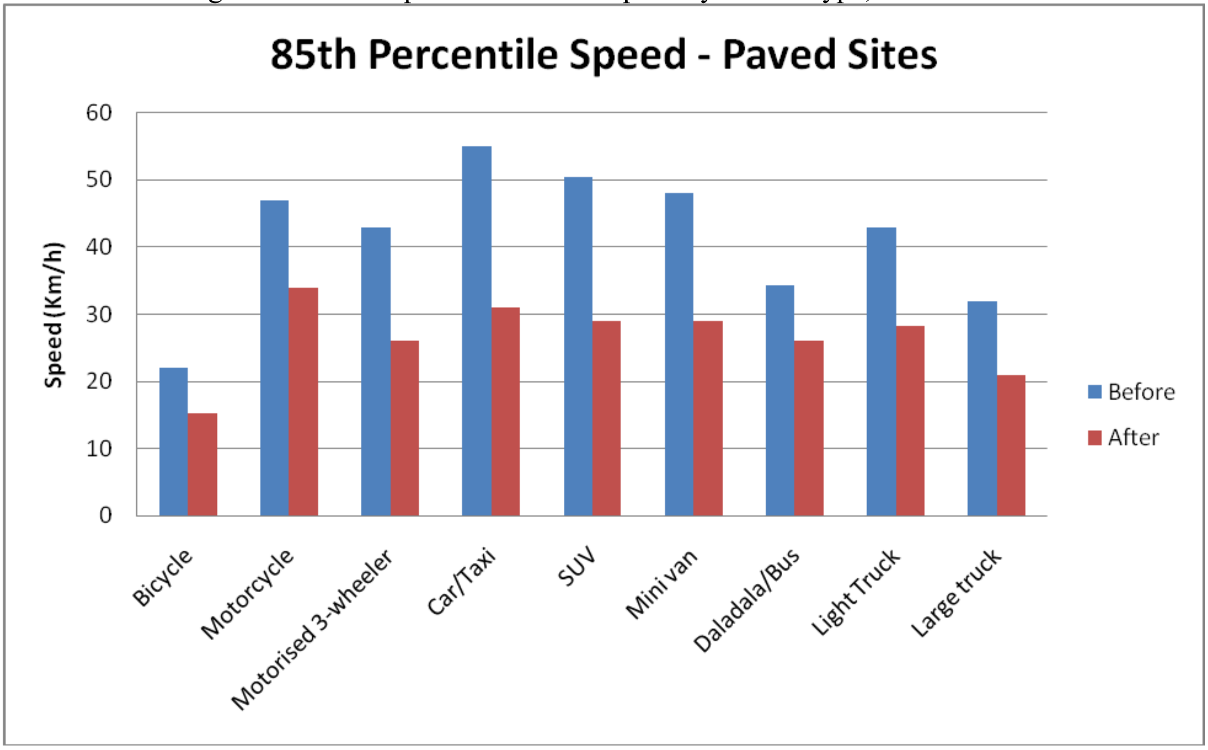

Figure 3: Pre- and post-intervention speed by vehicle type, paved sites

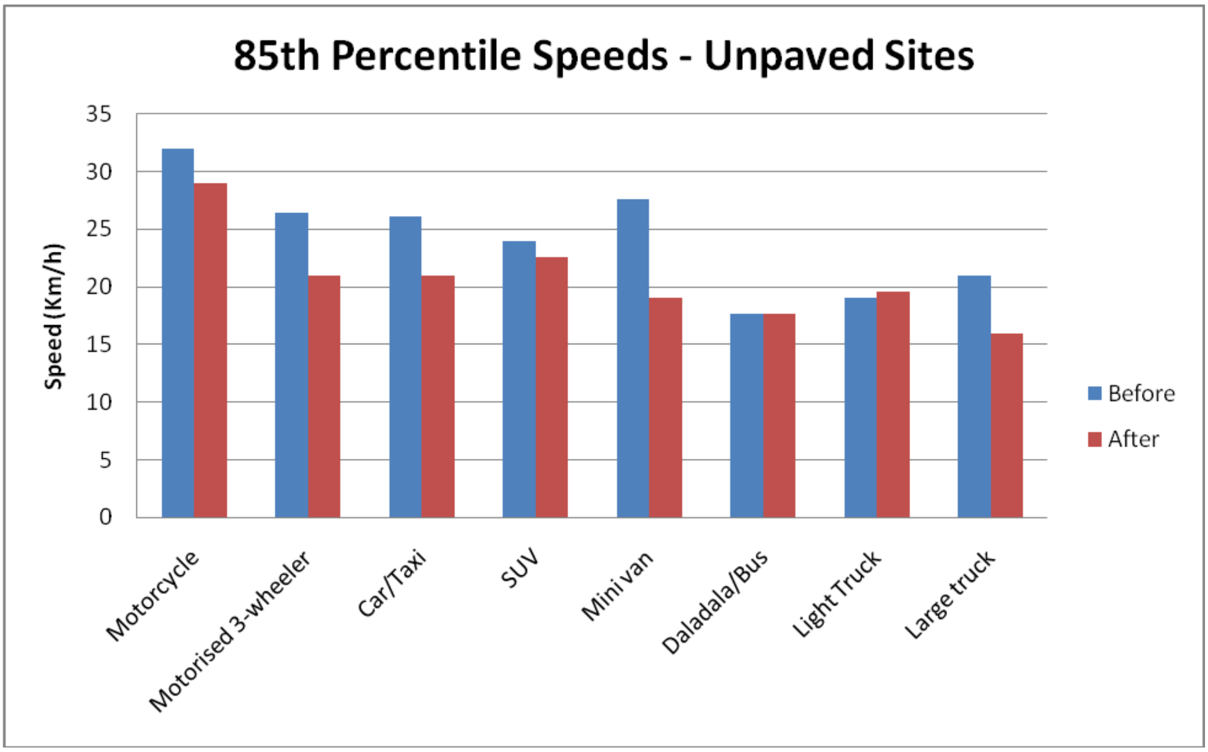

Figure 4: Pre- and post-intervention speed by vehicle type, unpaved sites

An unexpected outcome of the intervention was that where humps or rumble strips were placed on unpaved roads or paved roads without a kerb, motorcycles sometimes drove off the road, to avoid having to slow down. This posed a danger to pedestrians. A common locally available countermeasure was the use of old car tires, acting as bollards on either side of the speed humps.

Another challenge relates to the quality of infrastructure materials locally available in Dar es Salaam. It was found that thermoplastic paints used for zebra crossings generally did not last as long as they would have in other environments primarily because of the sandy nature of Dar es Salaam and the lack of regular maintenance.

4.0 CONCLUSON

Reduced vehicle speeds decrease both the probability of a vehicle hitting a pedestrian (World Health Organization, 2015), as well as the severity of the injury and likelihood of death if such an incident does occur. This study showed that low-cost interventions have the potential to reduce vehicle speeds and hence RTI rates and severity around school areas. Further evaluation will be performed as this study forms part of a larger impact control evaluation of the SARSAI programme, conducting speed assessments a year after implementation as well as looking at the impact of the reduced speeds on actual RTI rates and severity amongst the target population.

The study also highlighted the need for further research into appropriate counter measures to address the speeds of motorcycles and their disproportionate contribution to RTIs amongst primary school pupils in cities such as Dar es Salaam. Counter measures specific to unpaved roads also need to be explored further.

Government stakeholders should be engaged at all levels, to spread awareness and support for road safety programmes such as SARSAI. The ultimate goal is for countries to realize the importance of road safety, and prioritize and lead programmes such as SARSAI themselves.

Although our study did not monitor the effect of decreased speed and decreased RTI on air pollution, it is intuitive that as walking and cycling becomes safer, children will also be more inclined to used non-motorized transport to commute to school. The community will also be able to safely utilize non-motorized transport, thereby decreasing air pollution. Speed management can make transport safer, cleaner, fairer, and greener.

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4.1 What is already known about the subject

- The African region suffers the highest morbidity and mortality rates due to road traffic crashes.
- Roads are the leading cause of death among children ages 15-29.
- Speed has a direct correlation with the likelihood of death and injury due to a crash.

4.2 What this study adds

- An assessment of the potential to decrease RTI in school zones through speed management in low- and middle-income regions, to be used when comparing with other communities.
- Evidence of the effectiveness of low-cost methods of speed management to reduce RTI.
- Evidence of the effectiveness of utilizing quantitative studies to determine the effectiveness of speed management interventions.
- Evidence of the need for further studies focusing on speed counter measures specific to motorcycles and unpaved roads.

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Competing interest: None.

Ethics approval: This study involved minimal risk for observers and those being observed. As there was no interaction of the study team with any human subjects, no risk was posed to human subjects. No consent was obtained for the study.

Contributors: All authors have participated sufficiently in the work to take public responsibility for the content.

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